



Statistical Patterns in Aerosol Retrievals from NOAA/AVHRR & TRMM/VIRS

Alexander Ignatov, Istvan Laszlo, Nick Nalli
NOAA/NESDIS & CIRA

Acknowledgement:

L.Stowe, **N.Rao**, B.Wielicki, W.Miller, E.Geier,
D.Young, P.Minnis, R.Arduini, J.Coakley, N.Loeb,
S.Kato, T.Charlock, F.Rose, W.Su, W.Collins,
J.Sapper, C.Moeller, L.Hunt, K.Morris, L.Mathias



Platform/Sensor/Algorithm

AVHRR: $\lambda_1=0.63 \mu\text{m}$ $\lambda_2=0.83 \mu\text{m}$ ($\lambda_{3A}=1.61 \mu\text{m}$)

NOAA: 1981- pr; 70°S-70°N; ~1:30 pm; H=870 km; 9 days

VIRS: $\lambda_1=0.63 \mu\text{m}$ $\lambda_2=1.61 \mu\text{m}$

TRMM: 1997- pr; 40°S-40°N; full day; H=350 km; 45 days

Cloud Screening: Accurate / Different

Ignatov Stowe *JAS* 2002:

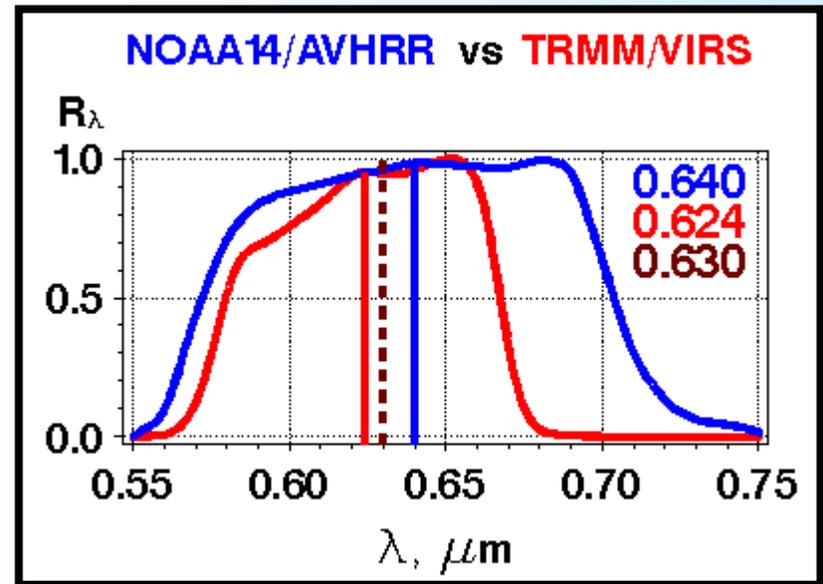
τ_1 : 6S-based (Vermote et al. *IEEE* 1997)
single-channel (scaled to $0.63 \mu\text{m}$)

Atmosphere

Aerosol: Log-Normal $R_m=0.1 \mu\text{m}$, $\sigma=2.03$; $n=1.4-0i$
(Empirical Phase Function; Ignatov *JAM* 1997)
Rayleigh/Gas: Mid-Latitude Summer

Surface

Lambertian: $\rho_{\text{sfc}}=0.002$ (0.2%)
Bi-directional: Cox-Munk $V=1 \text{ m s}^{-1}$



Why Single-Channel?

$$\rho \equiv \frac{\pi L}{F \mu_s}; \quad \rho = \frac{P^R(\chi) \tau^R}{4 \mu_s \mu_v} + \frac{\omega_o P^A(\chi) \tau}{4 \mu_s \mu_v}$$

Single-Channel: τ

- $\omega_o P^A$: fixed globally non-variable
(average aerosol type $\pm 30\%$)

Two-Channel: (τ, α) (Def: $\tau(\lambda) = \tau_o \times \lambda^{-\alpha}$)

- $\omega_o P^A$: adjusted coherently with retrieved α
(as accurate as α)

Information Content/Signal-To-Noise Ratio: $\eta = \sigma_{\alpha o} / \sigma_{\alpha}$

(Westwater Strand *JAS* 1968; Rogers *RGSP* 1976)

- $\sigma_{\alpha o} \sim 0.3$; $\sigma_{\alpha} \sim k/\tau$ (Ignatov et al. *ASR* 1997; Ignatov Stowe *JAS* 2002)
- $\eta = \tau/\tau_o$; $\eta \sim 1$ at $\tau \sim \tau_o$
- **AVHRR/AEROBS** $(8 \text{ km})^2$ $\tau_o \sim 0.18$ (Ignatov Stowe *JAS* 2002)
- **AVHRR/PATMOS** $(110 \text{ km})^2$ $\tau_o \sim 0.11$ (Ignatov Nalli *JTech* 2002)
- **TRMM/VIRS** $(>10 \text{ km})^2$ $\tau_o \sim ?$ (Under Analysis)



OBJECTIVE

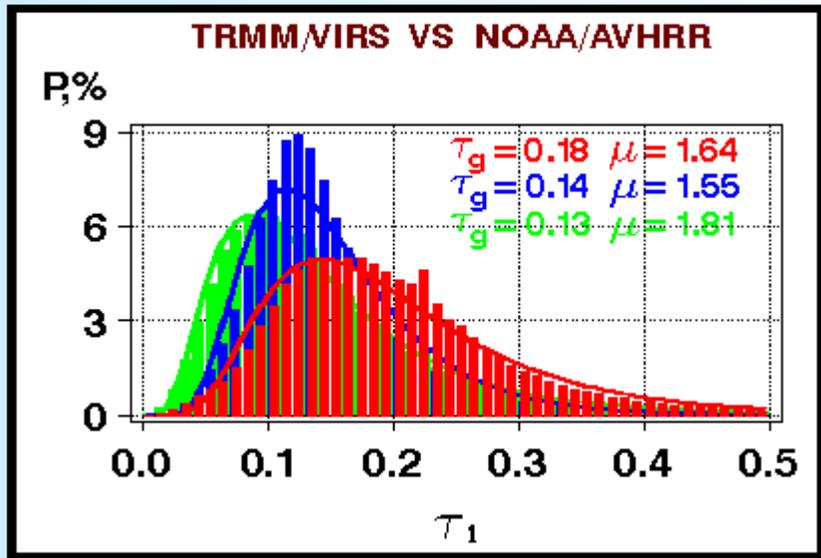
COMPARE STATISTICAL PATTERNS
IN VIRS & AVHRR τ_1

GLOBAL DATA

- **VIRS: 9 Days Apr 02-10 1998**
- **AVHRR: 10 Days Apr 01-10 1998**
- **AVHRR: GLOBAL PATMOS-BUOY
NOAA11 & 14 1990-1998**

VIRS	TRMM/VIRS SSF/Ed2 >10-km (N=605,214)
AVHRR (AEROBS)	NOAA-14 8-km (N=355,607)
AVHRR (PATMOS-BUOY)	NOAA-11 & -14 110-km (N=87,166)

HISTOGRAMS



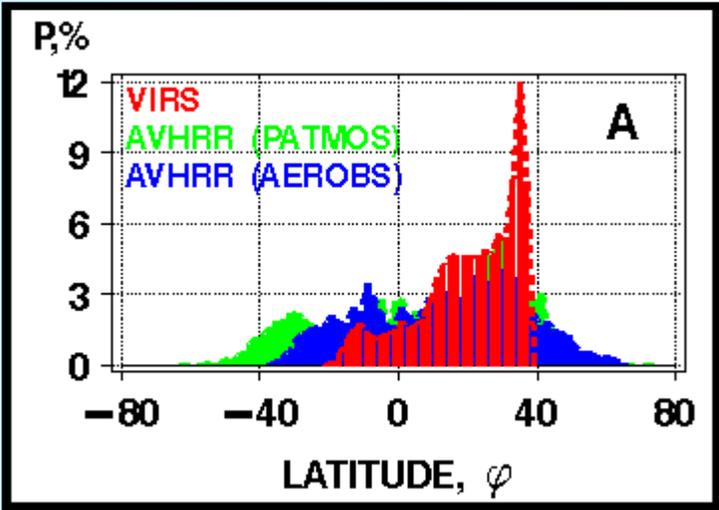
- **Log-Normal**
O'Neill et al. *GRL* 2000; Ignatov Stowe *JAS* 2002;
Ignatov Nalli *JTech* 2002
- **AVHRR ~ AVHRR << VIRS**

WHY DIFFERENT?

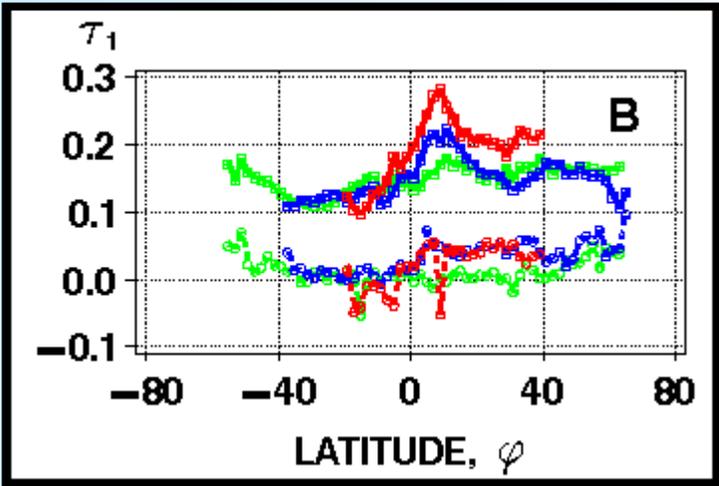
- **TRMM/VIRS:** 02-10 Apr 1998
- **NOAA14/AVHRR:** 01-10 Apr 1998
- **NOAA11&14/AVHRR:** 1991-94, 96-99

- **Sampling**
 - Space/Time
 - Scattering/Reflection Geometry
- **Cloud screening**
 - **VIRS:** Minnis et al. 1998
 - **AEROS:** Walton et al. 1998
 - **PATMOS: CLAVR** Stowe et al. 1999
- **Calibration (~6%: Ignatov AO 2002)**
 - **VIRS:** L.Nguyen et al. 2002
 - **AVHRR/AVHRR:** Rao Chen 1999

LATITUDE

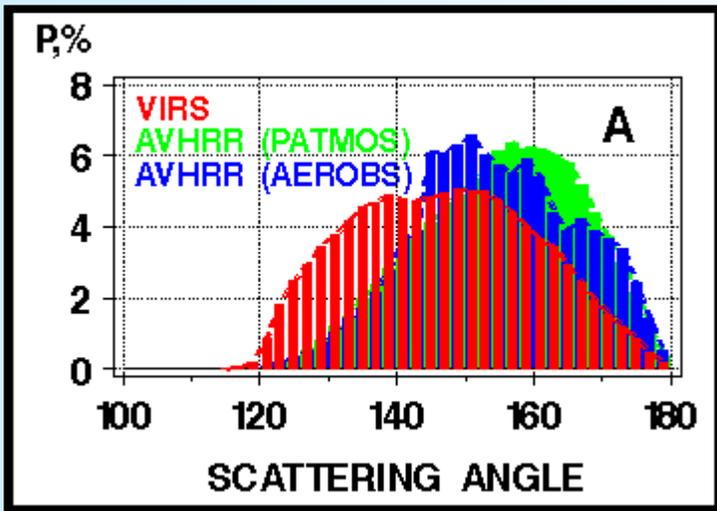


- **VIRS:** 20°S - 40°N
- **AVHRR:** 40°S - 60°N
- **AVHRR:** 60°S - 60°N

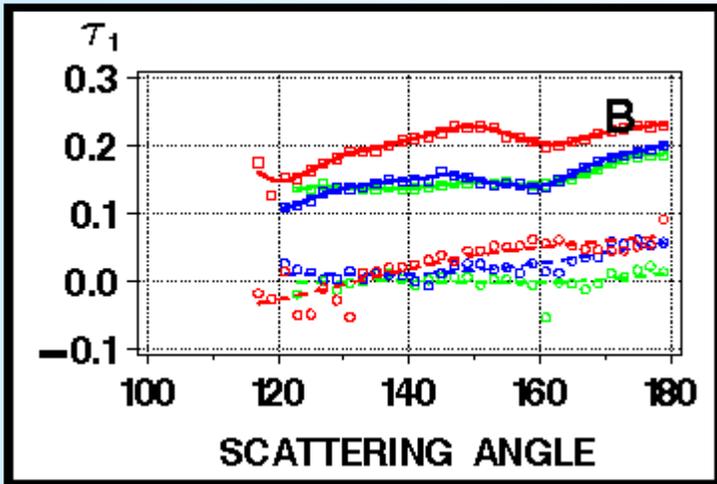


- **Minimum**
 - **VIRS** noisier (drop-outs)
 - **Min(VIRS) ~ min(AVHRR):** No Cal Error?
- **Average**
 - **AVHRR-AVHRR:** + Anomaly Apr98 (0-20°S)
 - **VIRS:** anomaly exaggerated

SCATTERING ANGLE

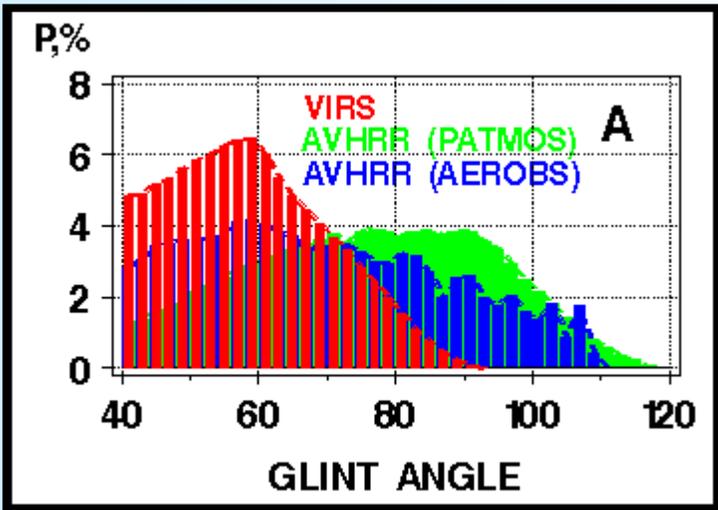


- **VIRS:** $\chi \sim 145^\circ$
- **AVHRR/AVHRR:** $\chi \sim 155^\circ$

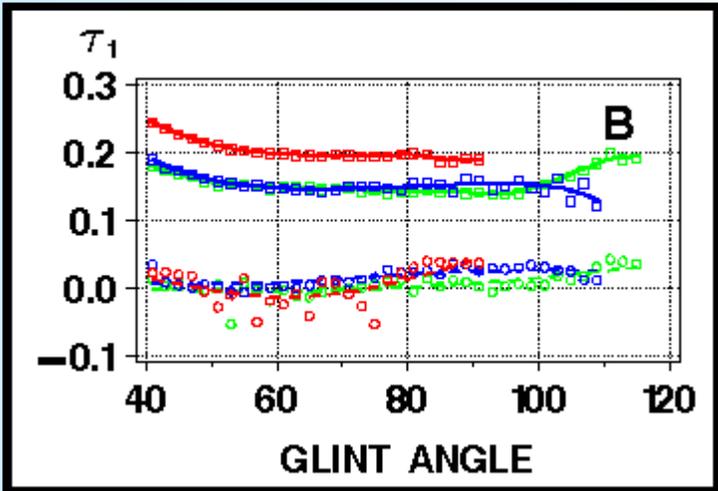


- **Average**
 - reproducible pattern for all data
 - flat at $\chi < 160^\circ$; increasing trend at $\chi > 160^\circ$
- **Minimum**
 - noise in **VIRS** at $\chi < 130^\circ$

GLINT ANGLE

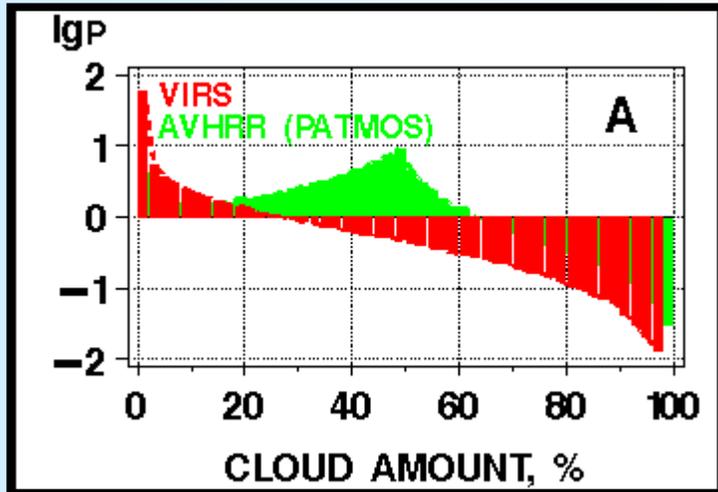


- **VIRS:** $\gamma \sim 60^\circ$
- **AVHRR/AVHRR:** $\gamma \sim 70^\circ$

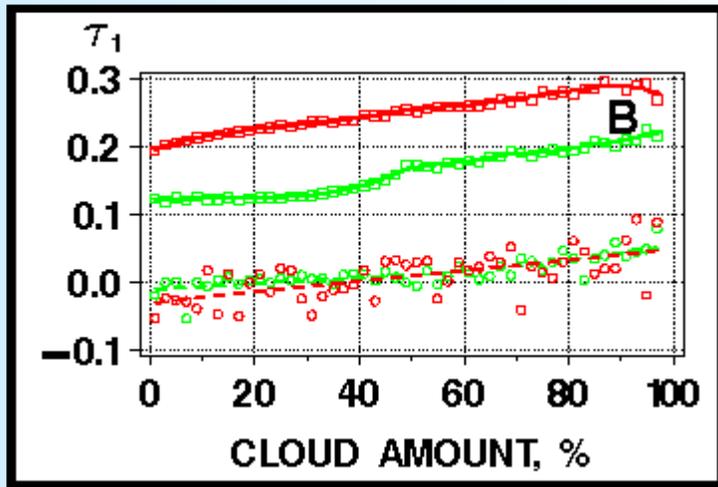


- **Average**
 - reproducible pattern for 3 datasets
 - flat at $\gamma > 55^\circ$; increasing trend at $\gamma < 55^\circ$
- **Minimum**
 - Consistent for all data

CLOUD AMOUNT



- **VIRS:** ~15%
- **AVHRR:** ~40%



- **Average**
 - reproducible pattern for 2 datasets
 - increasing trend with cloud amount
- **Minimum**
 - Increasing trend (residual cloud?)



CONCLUSION

- τ_1 Derived from AVHRR/VIRS Ch1 (0.63 μm) with single-channel algorithm
- α Difficult from AVHRR/VIRS for typical τ

Features in τ_1

- VIRS Biased High wrt AVHRR by $\sim +0.04$ (Sampling/Cal/Cloud)
- VIRS/AVHRR Trends Similar
 - Cloud Amount: Strong Correlation
 - Glint Angle: Flat at $\gamma > 55^\circ$; Elevated at $\gamma < 55^\circ$
 - Scatter Angle: Flat at $\chi < 160^\circ$; Elevated at $\chi > 160^\circ$

PLANS

- Resolve VIRS/AVHRR Differences
- Compare with MODIS/MISR